I CLAIM:

1. A method of determining characteristics of samples comprising:

A. building algorithms of the relationship between sample characteristics and absorbed and scattered light from a sample having an interior;

B. illuminating the interior of a sample with a frequency spectrum;

C. detecting the spectrum of absorbed and scattered light from the sample;

D. calculating the characteristics of the sample.

2. The method of claim 1 further comprising:

A. building the algorithms to generate a regression vector that relates the VIS and NIR spectra to brix, firmness, acidity, density, pH, color and external and internal defects and disorders;

B. storing the regression vector, in a CPU having a memory, as a prediction or classification calibration algorithm;

C. illuminating the sample interior with a spectrum of 250 to 1150nm;

D. inputting the detected spectrum of absorbed and scattered light from the sample interior to a spectrometer;

E. converting the detected spectrum from analog to digital and inputting the converted spectrum to a CPU; combining the spectrum detected;

F. comparing the combined spectrum with a stored calibration algorithm;

G. predicting the characteristics of the sample.

3 The method of claim 1 further comprising:

A. the characteristics are chemical characteristics including acidity, pH and sugar content

4. The method of claim 1 further comprising:

A. the characteristics are physical characteristics including firmness, density, color, appearance and internal and external defects and disorders.

5. The method of claim 1 further comprising:

A. the characteristics are consumer characteristics.

6. The method of claim 1 further comprising:

A. sampling is of samples from the group of C-H, N-H or O-H chemical groups;

B. illuminating of the interior of the sample is with a frequency spectrum including visible and near infrared light;

C. building algorithms for the correlation analysis separately of Brix, firmness, ph and acidity in relation to the light spectrum output from the illuminated sample;

D. detecting the spectrum of absorbed and scattered light from the sample with a light detector.

7. The method of claim 2 further comprising:

A. illuminating of the interior of the sample with a frequency spectrum of 250 to 1150 nm;

B. shielding the light detector fiber from the illuminating spectrum;

C. measuring the spectrum for chlorophyl at around 680 nm;

D. correlating the characteristics of Brix, firmness, pH and acidity with the measured spectrum.

8. An apparatus performing the method of claim 1 comprising:

A. at least one light source; a sample having an sample surface and an interior; input mechanism of positioning the at least one light source proximal the sample surface;

B. at least one light detector; output mechanism of positioning the at least one light detector proximal the sample surface;

C. at least one mechanism of measuring the illumination detected from the sample.

9. (Once Amended Preliminary to Office Action) The apparatus of claim 7 further comprising:

A. the at least one illumination source produces a spectrum within the range of 250 to 1150 nm;

B. the at least one mechanism of measuring the illumination is a spectrometer; the spectrometer has at least one input;

C. the at least one light detector is a light pickup fiber; the at least one light detector collects a spectrum which is received by the at least one spectrometer input; the spectrometer has at least one spectrometer output channel; a CPU having at least one CPU input; the at least one CPU input receiving the at least one spectrometer output; at least one computer program; the CPU is controlled by the at least one computer program; the CPU having at least one CPU output; the at least one computer program causing the at least one CPU output to perform the steps of 1) calculation of absorbance spectra 173 occurs for each at least one spectrometer output channel 1...n, 2) combine absorbance spectra 174 into a single spectrum encompassing the entire wavelength range detected from the sample by spectrometers 1...n 170, 3) mathematical preprocessing or preprocess 175, e.g., smoothing or box car smooth or calculate derivatives, precedes 4) the prediction or predict 176, for each at least one spectrometer output channel, comparing the preprocessed combined spectra 175 with at least one stored calibration spectrum or at least one calibration algorithm(s) 177 for each sample characteristic 1...x 178, e.g., brix, firmness, acidity, density, pH, color and external and internal defects and disorders, for which the sample is examined, followed by 5) decisions or further combinations and comparisons of the results of quantification of each characteristic, 1...x, e.g., determination of internal and or external defects of disorders 179, 180; determination of color 181; determination of indexes such as eating quality index 182, appearance quality index 183 and concluding with sorting or other decisions 184; 6) sorting or other decisions 184 may be input process controllers to control packing/sorting lines or may determine the time to harvest, time to remove from cold storage, and time to ship;

D. the sample is from the chemical group of C-H, N-O, and O-H.

9A. (Claim Added Preliminary to Office Action) The apparatus of claim 9 further comprising:

A. the at least one spectrometer output are converted from analog to digital by at least one A/D converter which become, for each at least one spectrometer output channel, input to at least one CPU input; the at least one CPU output provided for each at least one spectrometer output channel 1....n.

10. The apparatus of claim 8 further comprising:

A. the least one illumination source is a is a tungsten halogen lamp; the illumination is transmitted to the sample surface by fiber optics;

B. the at least one light detector is a fiber optics light pickup;

C. the at least one spectrometer comprises a 1026 linear array detector;

11. The apparatus of claim 9 further comprising:

A. the at least one illumination source is an illumination fiber.

12. The apparatus of claim 10 further comprising:

A. the at least one illumination source comprises a plurality of illumination fibers;

B. the plurality of illumination fibers are arrayed such that each illumination fiber is equidistant from adjoining illumination fibers; the at least one light detector is positioned centrally in the array of illumination fibers.

13. The apparatus of claim 11 further comprising:

A. the plurality of illumination fibers are comprised of 32 illumination fibers.

14. The apparatus of claim 11 further comprising:

A. the illumination source is a 5w tungsten halogen lamp.

15. The apparatus of claim 11 further comprising:

A. the plurality of illumination sources is comprised of two 50 w light sources;

B. the at least one light detector is comprised of a plurality of light detectors.

16. The apparatus of claim 14 further comprising:

A. the plurality of light detectors are arrayed such that each light detector is equidistant from adjoining light detectors.

17. The apparatus of claim 15 further comprising:

A. the plurality of light detectors comprise twenty-two light detectors.

18. The apparatus of claim 11 further comprising:

A. the illumination source comprised of an ellipsoidal reflector with having a 50 w bulb with cooling fan; the plurality of illumination fibers is comprised of at least one fiber optic fiber for transmission of the light source to the sample surface.

B. the at least one fiber optic and the at least one light detector spring biased against the sample surface; the pressure exerted by the spring biasing limited by the character of the sample.

19. The apparatus of claim 10 further comprising:

A. the at least one illumination source is a 5 w tungsten halogen lamp; the at least one light detector is a single fiber optic fiber; the illumination source is positioned against the sample surface 180 degrees distal to the detection fiber.

20. The apparatus of claim 11 further comprising:

A. a polarization filter is positioned between the at least one illumination source and the sample;

B. a matching polarization filter is positioned between the at least one light detector and the sample.

21. The apparatus of claim 19 further comprising:

A. the polarization filter is a linear polarization filter; the matching polarization filter is a linear polarization filter rotated 90 degrees in relation to the polarization filter.

22. An apparatus performing the method of claim 1 comprising:

A. at least one light source; a sample having an sample surface and an interior; input mechanism of positioning the at least one light source proximal the sample surface; at least one shutter intermediate the at least one light source and the sample; the at least one light source having a lamp output;

B. at least one light detector; output mechanism of positioning the at least one light detector proximal the sample surface; at least one collimating lens intermediate the at least one light detector and the sample surface; at least one mechanism of measuring the illumination detected from the sample surface;

C. at least one reference light detector directed to the lamp output; at least one shutter intermediate the at least one reference light detector and the at least one lamp output; at least one mechanism of measuring the illumination detected from the lamp output.

23. The method of claim 2 further comprising:

A. using the predicted characteristics of the sample in combination as follows: using the ratio of the sugar content to acid content to better predict eating quality, taste, sweet/sour ratio; using the combined data from two or more of the following: sugar content, acid content, pH, firmness, color, external and internal disorders to better predict eating quality.

24. The method of claim 2 further comprising:

A. sensing sample data including sensing by sample presence sensing means the presence or absence of a sample conveyed on a sample conveyor while in motion; sensing by sample position sensing means the position/location of the sample 30 relative to the point of spectrum measurement; presence sensing means and position sensing means having outputs to a computer program controlled CPU; the computer grogram controlled CPU determining if the sample 30 being measured is at the optimal location(s) for

spectrum measurement; the computer program controlled CPU determining if a sample is present.

24A The method of claim 24 further comprising:

A. presence sensing means is a proximity sensing means.

24B. The method of claim 24A further comprising:

A. position sensing means is an encoder or pulse generator 330 detecting sample conveyor 295 movement and providing one or more electronic or digital signals to a CPU 172 which initiates, by computer program control, control signals to initiate and stop acquisition of spectra.

24C. The method of claim 24B further comprising:

A. determining by computer program controlled CPU timing for performing reference testing of light source lamp, spectrometer performing of reference testing of light source lamps and of spectrometer receiving spectra input from detectors.

24D. The method of claim 24C further comprising:

A. testing of reference including measurement of dark spectra and/or reference spectra and/or standard/calibration samples.

24E. The method of claim 24D further comprising:

A. light source lamp light collection achieved using a collimating lens 78 and or other light transmission means including for example fiber-optics to transfer the light that has interacted with the sample 30 to the spectrometer(s) 170 detectors 200. If no sample 30 is present, other reference measurements are made to improve stability and accuracy such as previously mentioned dark spectra, reference spectra (lamp intensity and color output), and standard/calibration samples, which may be optical filters or polymers or organic material with known and repeatable spectral characteristics. Measurements that are made when no sample is present include, but are not limited to 1) measuring a reference spectrum (intensity vs. wavelength) of the light source(s), 2) measuring the dark current (no light conditions) of one or more spectrometer(s) 170 detector(s) 200, including but not

limited to the sample spectrometer(s) 170 and the reference spectrometer(s) 170, and 3) standard or calibration samples or filters 130 or material.

25. The apparatus of claim 8 further comprising:

A. sample presence sensing means for sensing of the presence or absence of a sample conveyed on a sample conveyor while in motion; sample position sensing means of the position/location of the sample 30 relative to the point of spectrum measurement; presence sensing means and position sensing means having outputs to a computer program controlled CPU; the computer grogram controlled CPU determining if the sample 30 being measured is at the optimal location(s) for spectrum measurement; the computer program controlled CPU determining if a sample is present.

25A The apparatus of claim 25 further comprising:

A. presence sensing means is a proximity sensing means.

25B. The apparatus of claim 25A further comprising:

A. position sensing means is an encoder or pulse generator 330 detecting sample conveyor 295 movement and providing one or more electronic or digital signals to a CPU 172 which initiates, by computer program control, control signals to initiate and stop acquisition of spectra.

25C. The apparatus of claim 25B further comprising:

A. computer program controlled CPU timing for performing reference testing of light source lamp, spectrometer performing of reference testing of light source lamps and of spectrometer receiving spectra input from detectors.

25D. The apparatus of claim 25C further comprising:

A. reference testing including measurement of dark spectra and/or reference spectra and/or standard/calibration samples.

25E. The apparatus of claim 25D further comprising:

A. light source lamp light collection achieved using a collimating lens 78 and or other light transmission means including for example fiber-optics to transfer the light that

has interacted with the sample 30 to the spectrometer(s) 170 detectors 200. If no sample 30 is present, other reference measurements are made to improve stability and accuracy such as previously mentioned dark spectra, reference spectra (lamp intensity and color output), and standard/calibration samples, which may be optical filters or polymers or organic material with known and repeatable spectral characteristics. Measurements that are made when no sample is present include, but are not limited to 1) measuring a reference spectrum (intensity vs. wavelength) of the light source(s), 2) measuring the dark current (no light conditions) of one or more spectrometer(s) 170 detector(s) 200, including but not limited to the sample spectrometer(s) 170 and the reference spectrometer(s) 170, and 3) standard or calibration samples or filters 130 or material.

26. The method of claim 2 further comprising:

A. measuring by reference measurement changes in light source lamp intensity or color output, a reference spectrometer output and output of spectrometer receiving sample spectra input from detectors; transmitting light from light source lamps to the reference spectrometer with detector using a reference light transmission means.

26A. The method of claim 26 further comprising:

A. using fiber-optics as the reference light transmission means.

26B. The method of claim 26 further comprising:

A. using a light pipe as the reference light transmission means.

26C. The method of claim 26 further comprising:

A. positioning the reference light transmission means, at the light source lamp, to allow only light from the light source lamp to enter the reference light transmission means.

26D. The method of claim 26C further comprising:

A. placing at least one light shutter intermediate each light source lamp and each reference light transmission means; opening and closing the at least one light shutter by shutter control means.

26E. The method of claim 26 further comprising:

A. measuring, by the reference spectrometer, each light source lamp separately; inputting the reference spectrometer output to the computer controlled CPU; storing in the CPU intensity vs. wavelength spectrum profile for each light source lamp; comparing the stored intensity vs. wavelength spectrum with the reference spectrometer output; determining from the comparison the condition of the light source lamp.

26F. The method of claim 2 further comprising:

A. using the detected spectrum as a reference spectrum, for purposes of calculating an absorbance (or log 1/R) spectrum, which is linear with concentration (e.g., percent Brix or acidity or pounds of firmness, etc.).

26G. The method of claim 26D further comprising:

A. closing all of the light shutters of the reference light transmission means; allowing a dark current (no light condition) measurement of the spectrometer 170 detector(s) 200; measuring the dark current and its intensity value at each wavelength (or detector) pixel; subtracting the measured dark current from a reference spectrum obtained with the shutters 330 open.

26H. The method of claim 26 further comprising:

A. measuring a reference spectrometer output and a sample spectrometer output dark current; shielding by shielding means, the input to the reference spectrometer and the input to the sample spectrometer; inputting the reference spectrometer output and the sample spectrometer to the computer controlled CPU; subtracting the output measured from the reference spectrometer; subtracting the output measured from the sample spectrometer.

27. The apparatus of claim 8 further comprising:

A. at least one light detector 80 having at least one output 82 to at least one spectrometer 170 having at least one detector 200; at least one colluminating lens 78 intermediate the at least one light detector 80 and a sample 30; the at least one light detector 80 positioned to detect light from the sample 30; at least one light source 120 lamp 123; a light shielding means intermediate the at least one light source 120 lamp 123 and a sample 30; at least one aperture 310 in the light shielding means to allow illumination of

the sample 30 by the at least one light source 120 lamp 123; at least one light interruption means intermediate the at least one light source 120 lamp 123 and the at least one aperture 310; the at least one light interruption means operable by at least one light interruption control means; the at least one light interruption control means receiving control signals from at least one CPU 172 having at least one light interruption operating control output; at least one reference light transmitting means receiving reference light output from the at least one light source 120 lamp 123; at least one reference light interruption means intermediate the at least one light source 120 lamp 123 and the at least one reference light transmitting means; the at least one reference light interruption means operable by at least one reference light interruption means control means; the at least one reference light interruption means control means 305 receiving control signals from at least one CPU 172 having at least one reference light interruption operating control output 307; the at least one reference light transmitting means 81 providing an input to the at least one spectrometer 170 detector 200; the at least one CPU 172 providing at least one lamp power output 125 to the at least one light source 120 lamp 123; the at least one spectrometer 170, receiving input from at least one reference light transmitting means 81 having at least one output 82 received as in input to the at least one CPU 172; the spectrometer output 82 capable of A/D conversion to form input to the at least one CPU 172; the at least one spectrometer 170, receiving input from at least one detector output 82 received as in input to the at least one CPU 172; the spectrometer output 82 capable of A/D conversion to form input to the at least one CPU 172; mounting means to mount light sources 120 lamps 123, detectors 80, light interruption means including shutters 300, shutter control means 305, reference light transmitting means 81 and case 250; encoder/pulse generator 330 input to CPU 172 providing sample conveyor 295 movement data; computer program to operate CPU 172 in data collection and control functions.

28. The method of 26 further comprising:

A. measuring, as a reference measurement, the light source 120 lamp(s) 123 intensity vs. wavelength output using reflecting means 360; positioning reflecting means 360 to reflect light from light source lamps to a light detector having a light detector output which is received by a spectrometer detector.

28A. The method of 28 further comprising:

A. positioning the reflecting means, by reflection position means, to a position to reflect light from light source lamps to a light detector as dictated by reflecting control means 308, as an output from a CPU 172, controlling the refection position means; the CPU 172, via means, detecting the presence or absence of a sample 30 and, when a reference measurement is to be made, inserting the reflecting means as dictated by reflecting control means 308 controlling the reflection position means as an output from a computer program controlled CPU 172; withdrawing the reflecting means as dictated by reflecting control means 308controlling the reflection position means as an output from a computer program controlled CPU 172.

29. The apparatus of claim 8 further comprising:

A. reflecting means, positioned by reflection position means, to a position to reflect light from light source lamps to a light detector as dictated by reflecting control means 308, as an output from a CPU 172, controlling the refection position means; the CPU 172, via means, detecting the presence or absence of a sample 30 and, when a reference measurement is to be made, inserting the reflecting means as dictated by reflecting control means 308 controlling the reflection position means as an output from a computer program controlled CPU 172; withdrawing the reflecting means as dictated by reflecting control means 308controlling the reflection position means as an output from a computer program controlled CPU 172.

30. The apparatus of claim 8 further comprising:

A. a light reflecting or diffusing body for obtaining the reference spectrum may also be obtained by mechanical insertion of reference means 430, as seen in Fig. 12 and Fig. 13, in or near the location where actual sample 30 is normally measured, which is between the light source 120 lamp(s) 123 and reference light transmission means 320

leading to the sample spectrometer 170 detector 200(s); insertion is by insertion means including but not limited to an actuator system 400 capable, upon receiving control signals or means as recognized by those of ordinary skill including control signals or means provided from a CPU 172, of operation of an actuator 410 causing a piston 420 to extend 421 and retract 422 as seen in Fig. 12 and 13; power, including for example electrical, pneumatic, hydraulic and other means, is provided to operate the actuator by power transmission means 440 as will be appreciated by those of ordinary skill.

31. The method of claim 2 further comprising:

A. illuminating, with at least one light source lamp, the sample interior while the sample is rolling or revolving, where a rolling measurement generally improving whole product measurement.

32. The method of claim 2 further comprising:

A. illuminating, with at least one light source lamp, the sample interior while the sample is not rolling or revolving, where a non-rolling measurement provides better accuracy and introduces less spectral noise due to movement.

33. The method of claim 2 further comprising:

A. obtaining, as a sample 30 passes by the point of spectrum acquisition, multiple spectra, where each spectrum representing a different measurement location or area on the product.

34. The method of claim 2 further comprising:

A. optimizing signal-to-noise and accuracy with small and large samples by 1) determining the size or weight of the sample by weight or mass sensors common to the industry; 2) utilizing a color sorter or defect sorter to provide data, e.g., from camera or CCD images; 3) utilizing other size sensors based on magnetic, inductive, light reflectance or multiple light beam curtains, common to other industries.

34A. The method of claim 34 further comprising:

A. adjusting, in accordance with the relative size of the sample, the hardware spectrum acquisition parameters or the amount of light, e.g., by varying an aperture 310 size, to provide an improved signal-to-noise ratio spectrum for large samples 30 and/or to prevent detector 80 saturation by light for small product sample 30, e.g., detector 80 exposure or integration time can be set for longer time periods for large product samples 30 and for shorter time periods for small product.

35. The method of claim 2 further comprising:

A. improving accuracy by inspection of multiple individual spectra collected from a single sample; removing poor quality or "outlier" spectra; calculating the absorbance spectrum from the raw data collected for dark, reference and sample; inspecting each individual spectrum from the series or batch of spectra acquired for each individual product sample by a computer program controlled CPU or by programmed hardware; deleting poor quality spectra from this batch of spectra, using the remaining spectra for constituent or property prediction; combining the retained spectra of the product sample with the appropriate reference and dark current measurements to produce an absorbance spectrum as follows: absorbance spectrum = -log10 [(sample intensity spectrum- sample dark current spectrum) / (reference intensity spectrum – reference dark current spectrum)] i.e. the absorbance spectrum is equal to the negative logarithm (base 10) of the ratio of the dark current corrected sample spectrum to the dark current corrected reference spectrum.

36. The method of claim 35 further comprising:

A. combining all of the absorbance spectra for each product sample to produce a mean or average absorbance spectrum of the product sample; using this average absorbance spectra to compute the sample component, characteristic or property of interest based on a previously stored calibration algorithm.

37. The method of claim 35 further comprising:

A. using each absorbance spectrum individually with the previously stored calibration algorithm to compute multiple results of the sample component, characteristic or property of interest for an individual product sample; determining the average or mean component,

characteristic or property of interest by summing all of the values and dividing the resultant sum by the number of absorbance spectra used.

38. The method of claim 2 further comprising:

A. measuring samples and linking location on product sample where visible/NIR data was collected with the same location that will be measured by the laboratory reference technique; calibrating performed as follows: 1) measuring spectra of product sample 30 and measuring absorbance spectra; correcting for reference and dark current and storing measurements; 2) undertaking standard laboratory measurements on the product sample 30; observing that it is important to the success of the NIR method that the portion of the sample 30 that is interrogated between the light source(s) 120 lamps 123 and light collection(s) detectors, e.g., light detectors 80, leading to the spectrometer(s) 170 detectors 200 is the same as that portion measured by the standard laboratory technique.

38A. The method of claim 38 further comprising:

A. transporting samples, by a sample conveyors 295, to the NIR measurement location including to a light detector; selecting rolling or not rolling sample conveyor 295 means; where rolling analyzing the entire sample for the component, characteristic or property of interest; averaging, if calibration algorithms are constructed in this way (using measurements of rolling product), all of the retained spectra for that individual product to produce an average absorbance spectrum and the total product component or property is assigned to this one absorbance spectrum.

38B. The method of claim 38 further comprising:

A. transporting samples, by a sample conveyor 295, to the NIR measurement location including to a light detector; selection not rolling sample conveyor 295 means; performing laboratory measurements on the same portion of product sample 30 that spectra were taken from; determining whether to separate a sample into smaller sub-portions prior to laboratory analysis; adjusting the time period of NIR data acquisition to shorter or longer times, corresponding to the measurement of smaller or larger product samples 30, respectively; associating, with each sub-portion of the product sample 30, one or more spectra associated with that particular location;

assigning the laboratory determined component, characteristic or property of interest to each spectrum or spectra from that particular location.

39. The method of claim 2 further comprising:

A. preforming mathematical processing on absorbance spectra prior to conducting statistical correlation analysis and calibration model building; pre-processing absorbance spectra using a bin and smooth function; relating by Partial least squares analysis (or variants thereof such as piecewise direct standardization) the processed absorbance spectrum to the assigned component and property values such as Brix, acidity, pH, firmness, color, internal or external disorder severity and type, and eating quality.

40. The method of claim 2 further comprising:

A. minimizing the number of samples needed to develop a calibration model; collecting spectra on all test samples; performing, prior to destructive laboratory measurements, principal components analysis (PCA) on the absorbance spectra; generating Resultant Score plots from PCA (e.g., Score 1 vs. Score 2, Score 3 vs. Score 4, etc.); selecting a subset of the original samples (e.g., 40% of the original number of samples) from the Score plots in either a random fashion or by selecting samples that, as a group, yield a similar range, mean and standard deviation of score values compared to the entire group of original samples 30.

41. The method of claim 40 further comprising:

A. periodically requiring calibration updates to maintain measurement accuracy; minimizing the efforts of calibration updates; analyzing, as fruit or vegetable samples are in a packing and sorting warehouse, the visible/near infrared spectra; examining by computer program controlled CPU, and determining if the sample qualifies as a potential calibration update sample; selecting calibration update samples 30 which cover low to high component values and which have Score values that cover the same range as the original sample's 30 Score values.